



Dredging Research

Technical Notes



Application Criteria for the Automated Real-Time Tidal Elevation System (ARTTES)

Purpose

This technical note describes application criteria for the Automated Real-Time Tidal Elevation System (ARTTES) used for offshore vertical water level control during survey and dredging operations. The criteria are formulated to permit those involved in offshore dredging operations to determine whether an ARTTES system may be of potential aid in planned or ongoing dredging projects.

Background

ARTTES systems are presently being operated in support of two large-scale channel deepening projects, one by the Jacksonville District at Saint Marys River entrance, the other by the Charleston District at the entrance channel to Charleston Harbor. Because the systems are site specific, questions have arisen in the field as to where and under what economic conditions these systems might be suitable for other dredging projects. While each dredging project ultimately must be assessed on an individual basis, some general criteria can be used to eliminate projects for which the systems are ill suited or unnecessary. The criteria discussed herein are minimal in the sense that meeting all of them indicates only that a project is a good candidate, not necessarily that a system is feasible or required.

Additional Information

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Introduction

A long-standing problem associated with coastal and offshore dredging operations has been accounting for tidal effects in hydrographic surveys and in the dredging process itself to assure that design channel depth has been reached and to aid determination of the quantity of material moved in order to compute payment. The shift from US Army Corps of Engineers owned and operated dredging equipment to contract dredging operations brought with it the need for more accurate specification of channel cross sections and dimensions. However, more accurate channel specifications are relevant only if means exist to ensure the specifications are met. In addition, requirements to dredge to greater depths and greater distances offshore have emphasized the monetary consequences of inaccurate channel measurements. Because credible water level data typically are scarce or absent at offshore locations, disputes between the Corps of Engineers and contractors have arisen as to the amount of material dredged and the payment due.

An obvious means of acquiring offshore tide data is to install a platform or tower or series of platforms or towers, each with a transmitting tide gage, along the channel to be dredged. While conceptually straightforward, this scheme typically has a very high initial cost and tends to be very maintenance intensive. The high maintenance costs are due primarily to the requirements to maintain a vertically stable platform in areas with heavy marine traffic and to provide a reliable, independent power source for operation of each sensor suite and transmitter.

At the request of the Jacksonville District, an alternative system was developed to support deepening of the entrance channel to the US Navy Trident Submarine Base at Kings Bay, GA. The design project depth of 46 ft relative to Mean Low Water requires an entrance channel extending approximately 13 miles seaward of the ends of the jetties. Because the system is used by contractors as well as District survey vessels, the system was designed from the onset to be used by relatively unskilled persons with little "hands on" intervention and investment in user equipment. The system was designated the Automated Real-Time Tidal Elevation System and took the acronym ARTTES.

The ARTTES allows virtually unlimited numbers of users to obtain instantaneous tidal elevation data over a designated area. It is based on a predictor-corrector method and consists of a high precision water level sensor linked to a VHF transmitter which continuously broadcasts the water level as measured at some location in the designated area. Users have a VHF receiver linked to a lap-type or desktop computer. Resident on the computer is communication/computation software which predicts the tide level at a user-specified location based on data previously acquired within the designated area. The predicted water level is corrected for nontidal effects using data received via the radio transmitter and is then displayed to the operator. The

system permits highly repeatable elevation control during offshore surveys. Moreover, it can allow dredge operators to make online adjustments for changes in water level, thus minimizing the need to overdredge. Figure 1 is a schematic diagram outlining operation of the system. A detailed description of the system is given in Lillycrop and others (1988).

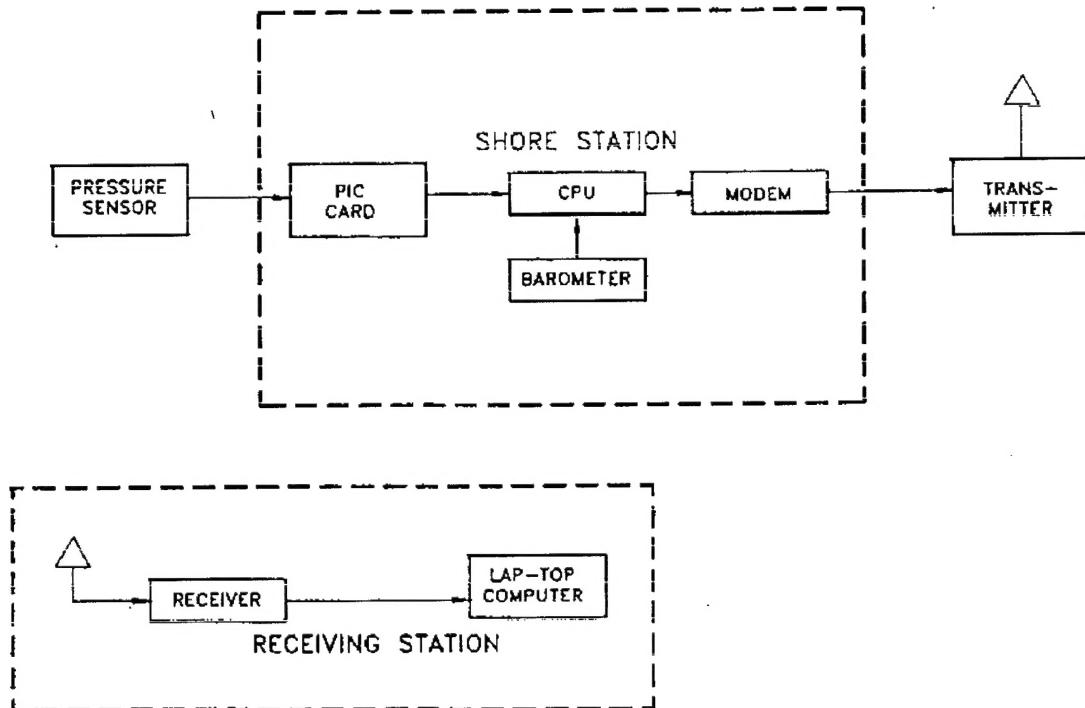


Figure 1. Automated Real-Time Tidal Elevation System

Application Criteria

The criteria for determining the applicability of an ARTTES fall into two general categories—technical and economic. The technical criteria include both objective and subjective aspects. The economic criteria include aspects which may be unknown at the time a decision is required, making some assumptions necessary.

Technical Criteria

The ARTTES is applicable only to nearshore, open-ocean areas, that is, seaward of the mouth of a river or jetty system up to approximately 20 miles offshore. Dredging and survey operations requiring tide data within the reaches of jetties or into estuaries and rivers are better served using other techniques or systems. The limit of 20 miles is due to the present type of radio

transmitter being used. A more powerful transmitter could be used to extend the range.

Bathymetry of the candidate area should be reasonably well represented by one or a series of linear slopes. The series of slopes should rise monotonically in the onshore direction. The channel area should be free of deep marine canyons and very shallow shoals, especially any that are exposed during only part of the normal tide cycle. Current bathymetric or navigational charts of the vicinity are usually adequate to determine whether the area is suitable for ARTTES application from a bathymetric standpoint.

At least 80 percent of the annual water variance at the candidate site must be due to the astronomic forced tide. National Ocean Service (NOS) tide data for the general vicinity can be used to determine whether this criterion is met. Most locations along the Atlantic and Gulf of Mexico and many along the Pacific coastlines of the continental United States meet this criterion.

There should be significant differences in the range and/or phase of the tide along the extent of the channel. Differences of 15 to 20 percent in range are common in shallow coastal areas where dredging often occurs. Where the tide range is small (for example, 2 ft), differences may be only a few tenths of a foot, perhaps small enough to be of no significant concern. Where the tide range is greater (for example, 6 ft), differences may exceed 1 ft and have to be considered if accurate survey and dredging are to be conducted.

Economic Criteria

Based upon recent contracts awarded by Charleston, Galveston, and Jacksonville Districts, typical costs for offshore dredging range from about \$1.50/cu yd to \$3.50/cu yd. Use of an ARTTES reduces the vertical root mean square uncertainty in offshore survey and dredging operation from about 1.5 to 0.5 ft. For a typical entrance channel width of 800 ft, use of the system reduces the amount of dredging required to assure a given channel depth by 156,000 cu yd per statute mile of channel. Assuming an average dredging cost of \$2.00/cu yd, this translates to saving about \$312,000 per statute mile of channel.

The present initial cost of an ARTTES is \$250,000 to \$300,000, depending upon site-specific characteristics. Therefore, for a deepening project, wherein the channel will be dredged along the entire length, use of a system can produce net savings for channels more than 1 mile long.

For maintenance dredging operations, identification of savings by use of a system is more complicated. Typical maintenance cost for an ARTTES is about \$50,000 per year. Assuming a 10-year system life, initial cost plus

maintenance is a total of about \$700,000 or \$70,000 per year. Again, assuming a \$2.00/cu yd dredging cost, the system would have to eliminate 35,000 cu yd of annual maintenance dredging to be economically justifiable. Since the system reduces the amount of dredging required to achieve design depth by about 0.3 cu yd for each square yard, the annual dredging project would have to cover a minimum of 115,000 sq yd. For a typical channel width of 800 ft, this is equivalent to about 1,300 lin ft of channel.

Secondary, more intangible sources of cost savings can result from more accurate identification of areas requiring dredging, better estimates of quantities to be dredged to assure design depth, and reduced risk of contractor claims resulting from disputes over quantities.

Conclusions

Maintaining a real-time tide gage in a channel is, in principle, a simple matter. However, experience indicates that there is considerable difficulty in maintaining such a gage and assuring a stable vertical datum in an area with normal navigational traffic and commercial fishing interests. The problem is compounded by the requirement to have some means of cross checking the data in order to alert users to system problems other than complete failure. Users who are tempted to use something "simple and inexpensive" are cautioned that the offshore dredging environment is one in which there is strict application of Murphy's Law. Those in the user community who need to establish offshore tide control, regardless of whether an ARTTES system is the best solution, are urged to contact the author of this Technical Note or the Program Manager of the Dredging Research Program.

Reference

Lillycrop, W. J., Howell, G. L., Garcia, A. W., Grogg, W. E., and Andrew, M. E. 1988. "An Automated Real Time Tide Elevation System," *Proceedings, US Army Corps of Engineers Surveying Conference*, Savannah, GA.

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